

## SECTION VI

### WATER QUALITY MONITORING PROGRAM

#### A. INTRODUCTION

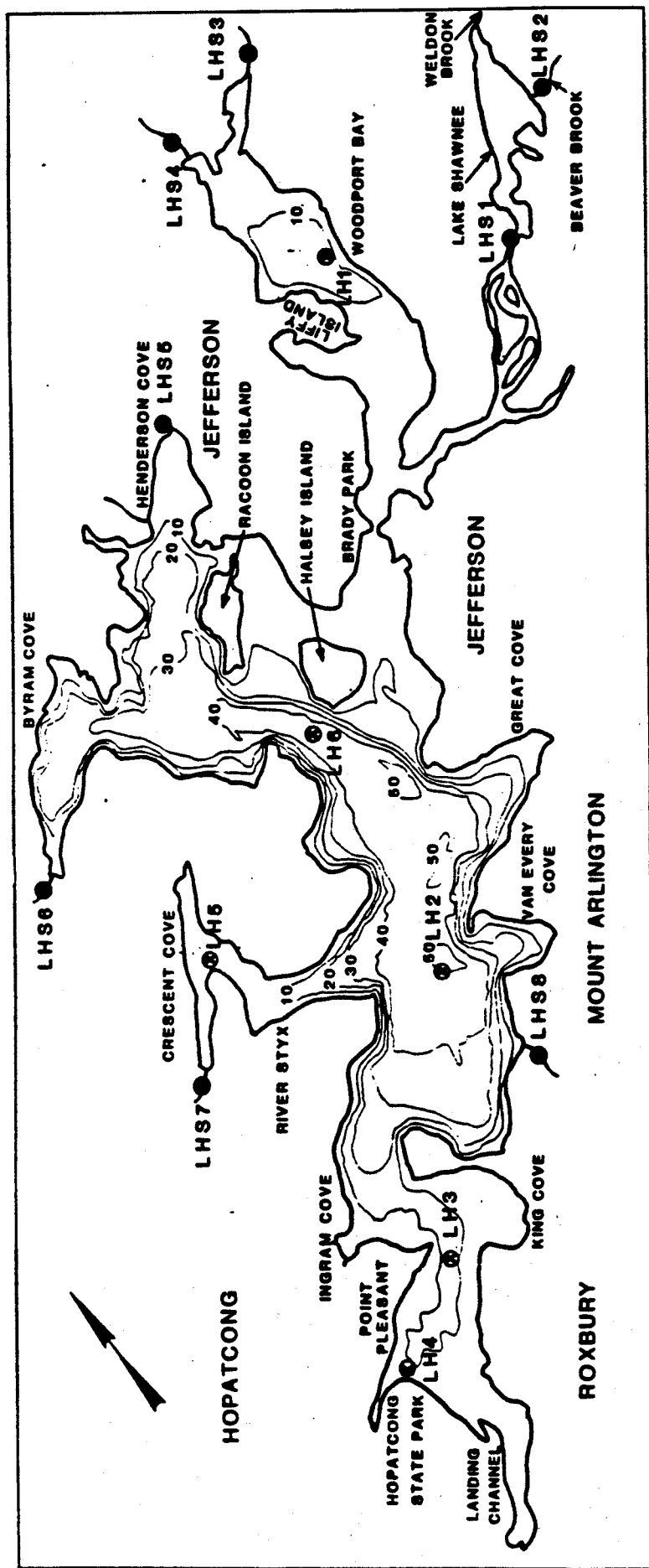
In order to establish the existing conditions of the lake and its tributaries, ascertain historical trends in the degradation of the lake's water quality, and identify the interrelationships among the physical-chemical-biological components of Lake Hopatcong, a detailed water quality monitoring program was conducted. The goal of this program was to identify the problems of Lake Hopatcong and develop, from this data, an effective restoration action plan. The methodologies utilized in this study were designed to generate data which would provide a sound framework for the selection of appropriate restorative and management techniques. In this manner, the problems and features unique to Lake Hopatcong and its surrounding watershed will be properly addressed.

## B. STATION SELECTION AND LOCATION

A total of 6 in-lake stations and 8 tributary stations were monitored on a regular basis (Table 19, Figure 4). The lake stations were monitored bi-weekly from April through September, and monthly the remaining months. The tributary stations were monitored on a monthly basis year-round. Additional stations were selected and monitored on a more infrequent basis for storm contributions, sediment composition, surveys of the fish, benthos, and macrophytes, and septic and sewage contributions. The location and frequency of these sampling programs will be addressed in those sections and sub-sections of this report which address these areas in more detail.

Table 19  
IN-LAKE AND STREAM SAMPLING STATIONS

<u>Designation</u>	<u>Location</u>
Stream Stations:	
LHS 1	Lake Shawnee Dam overflow
LHS 2	Outfall from Weldon Brook into Lake Shawnee
LHS 3	Outfall from Lake Wenona into Lake Hopatcong
LHS 4	Stream under Prospect Point Road at north end of Woodport Bay
LHS 5	Jayne Brook at Lakeside Avenue
LHS 6	Stream under Maxim Drive that flows into southwest end of Byram Cove
LHS 7	Stream under Crescent Road with storm sewers that flow into southwest corner of Crescent Cove
LHS 8	Stream at foot of Altenbrand Road
Lake Stations:	
LH 1	Woodport Bay
LH 2	Main basin, off Chestnut Point
LH 3	Point Pleasant
LH 4	In vicinity of spillway near Hopatcong State Park
LH 5	Center of Crescent Cove
LH 6	Southwest side of Halsey Island



# LAKE HOPATCONG REGIONAL PLANNING BOARD LAKE RESTORATION AND MANAGEMENT STUDY

FIGURE 4

LAKE AND STREAM SAMPLING STATIONS

## C. METHODS AND MATERIALS

### 1. In-Lake Sampling Program

A non-metallic Kemmerer sampling bottle was used to collect in-lake water samples. The water column at lake stations LH1, LH3, and LH6 was sampled 0.5m below the surface, and 0.5m above the bottom. Lake Station LH2, the deepest spot in the lake, was sampled at six depths; 0.5m, 3.0m, 6.0m, 9.0m, 12.0m, and 0.5m above the bottom. Samples were collected from only one depth, halfway between surface and bottom, at the shallow lake stations LH5 and LH4.

Water quality samples were collected, preserved, and transported to PAS laboratory facilities for analysis following EPA accepted methods. Quality control was in keeping with the guidelines developed by the State of New Jersey as detailed in the Quality Control Assurance Plan for the PAS Laboratory (PAS, 1982).

In situ measurements of air temperature, wind speed and direction, surface water temperature, and Secchi disc transparency were recorded for each sampling station. The temperature/dissolved oxygen profile at each station was measured using a Rexnord portable temperature/dissolved oxygen probe. The pH of each sample was determined immediately upon collection.

Water samples to be analysed by the PAS laboratory, were dispensed from the Kemmerer sampling bottle into polyethylene containers. Four 1 liter samples were obtained at each sampling depth for each lake station. One was preserved with sulfuric acid, another with Lugol's solution, and the remaining two left unpreserved. From each of the appropriately preserved bottles, the following parameters were analysed as per

Standard Methods for the Examination of Water and Wastewater 14th ed.  
(1975), and in accordance with 40 CFR 136 et. seq.

Preserved with sulfuric acid

- total kjeldahl nitrogen
- nitrate and nitrite-nitrogen
- ammonia nitrogen
- total nitrogen
- total phosphate-phosphorus

Preserved with Lugol's solution

- whole phytoplankton

No preservative

- chlorophyll a, b, and c; phaeophyton (1 liter)
- orthophosphate-phosphorus
- suspended solids
- turbidity
- alkalinity
- specific conductance
- hardness
- pH

Net phytoplankton and zooplankton were also collected at each station on each sampling date except during ice cover. A 60 micron net was used to collect phytoplankton and a 153 micron net was used to collect zooplankton. Both nets were towed obliquely, at an approximate depth of 0.5 meters, for a set duration (usually 1 minute), and a set speed (usually 0.5 knots). Samples were transferred to 10 ml vials. The 60 u

net sample was preserved with a formalin-copper sulfate solution whereas the 153 u net sample was preserved with a buffered formalin-rosebengal solution. Phytoplankton were identified to genus.

In addition to the above routine analyses, periodic sampling of the benthos, aquatic plants, fish, and sewage/septage related bacteria were conducted.

Benthic samples were collected using a 229 mm x 229 mm x 229 mm Ekman dredge. Bottom samples were sifted through 2000 mm and 1000 mm screens, the retained organisms picked, transferred to 10 ml vials, and preserved with a formalin-rosebengal solution. In the laboratory, organisms were identified to the lowest possible taxa following the criteria of Pennak (1978), Ward and Whipple (1966), and Merritt and Cummins (1978).

A survey of the lake's fishery was conducted using haul seine equipment. Species were identified in the field, and their weight, length, sex, and total numbers recorded.

A combination of SCUBA and surface techniques were employed to determine the extent, density, and species composition of the aquatic macrophytes of Lake Hopatcong. Transects were established from which samples were collected and semi-quantitative observations made. At a number of sites, all plants within a 1000 cm<sup>2</sup> quadrant were harvested. Upon return to the laboratory, the plant material was washed, sorted, and identified to species. The wet weight, ash weight, and organic content were determined. In addition, the concentration of total phosphorus, total kjeldahl nitrogen, and metals of a few sub-samples were measured. The chemical and biological methodologies recommended in Standard Methods for the Examination of Water and Wastewater, 14th ed. (1975), and Weber (1973) were followed.

The sediments of the lake were sampled using a K-B freefall coring device. The depth of the sediments were recorded in the field along with observations related to the color, texture, and oxic nature of the sediments. Sediment cores were iced upon collection and transferred in an upright position. Immediately upon return to the laboratory the redox potential of the sediments were recorded using an Orion Research redox probe. The sediment cores were then frozen. The frozen cores were extruded from the core tubes and cut into three strata (top, middle, and bottom). The following analyses were performed on each of these subsamples:

- particle size
- organic matter
- total phosphorus
- total nitrogen

A composite sample from each core was analyzed for persistent organics and heavy metals. E.P. toxicity tests were also conducted on the leachate of the sediments. All analyses were performed in accordance with Standard Methods for the Examination of Water and Wastewater, 14th ed. (1975) and 40 CFR 136 et. seq.

Fecal coliform, total coliform and fecal streptococcus bacteria were periodically monitored. The membrane filter methodology outlined in Standard Methods for the Examination of Water and Wastewater 14th ed. (1975) was followed. Data were reported as most probable number (MPN) per 100 ml.



## 2. Stream Sampling Program

Monthly surface grab water samples were collected from mid-channel at each of the stream stations. A total of eight tributary stations were sampled. The location of each station is noted on Figure 4, and listed in Table 19.

Future reference to these stations will be made using the LHS nomenclature.

Samples were collected in two 1 liter polyethylene containers. One container was preserved with sulfuric acid, and the other left unpreserved. Samples were stored on ice and transported to PAS laboratory facilities for analysis. From the appropriately fixed containers, the following parameters were analysed:

### Preserved with sulfuric acid

- total kjeldahl nitrogen
- nitrite and nitrate-nitrogen
- ammonia nitrogen
- total nitrogen
- total phosphate-phosphorus

### Non-preserved

- orthophosphate-phosphorus
- suspended solids
- turbidity
- specific conductance
- alkalinity
- hardness

In-situ measurements of pH, air and water temperature, and windspeed and direction were recorded, and general meteorological conditions noted.

Precipitation in the watershed was measured and recorded by a LHRPB volunteer. Precipitation records maintained by the National Oceanic Atmospheric Administration (NOAA) for the Lake Hopatcong area were used as a means of verifying their accuracy.

### 3. Point Source Sampling Program

There are four sewage treatment plants (STPs) located within the watershed of Lake Hopatcong which discharge to the lake's tributaries. Each point source discharge was identified by name, location, New Jersey Pollution Discharge Elimination System (NJPDDES) permit number, receiving stream, and maximum allowable flow.

Physical, chemical and biological parameters were monitored at each point source. Samples were collected by means of grab and automated samplers, and composited over peak four-hour flow (10:00 to 14:00). The following parameters were analysed:

BOD<sub>5</sub>

Suspended Solids

pH (in situ)

Fecal coliform

Temperature

Total organic carbon

Total phosphorus

Orthophosphate-phosphorus  
Total kjeldahl nitrogen  
Nitrite and nitrate-nitrogen  
Ammonia nitrogen.

Peak four hour flow composite data were evaluated with respect to loading of nutrients, sediment, organics and biochemical oxygen demand. Data were compared and evaluated relative to the National Eutrophication Survey data, NJPDES data, and existing permits for the point sources.

#### 4. Evaluation of Septic Contributions

Nutrient contributions associated with improperly operating on site waste disposal systems were assessed. Although such nutrient loads were ultimately quantified using the methodology outlined in NES Working Paper #175 (USEPA, 1976), various survey techniques were employed to determine the potential number of failing septic systems in the immediate (100-200 m) proximity of the lake's shoreline.

Potentially failing systems were located by means of aerial infrared photography and the use of portable fluorescence-conductivity meter, commonly called a "septic snooper".

The infrared aerial photographs of the lake basin were taken by EPA personnel using a wing-strut mounted enviro-pod camera. The photographs were shot in March 1982 at an altitude of 350 meters (1,000 ft).

An in-lake survey of possible septic plumes was conducted using the "septic snooper". With the septic snooper mounted in a small boat and the sampling probe lowered overboard and submerged 0.5 m, a continuous

scan of fluorescence and conductivity was obtained as the boat motored slowly around the lake's perimeter. Background fluorescence and conductivity were factored through calibration of the unit at a deep water mid-lake station. Full details regarding the calibration and use of the unit are presented in the "ENDECO Type 2100 Septic Leachate Detector System Operators Manual" (Kerfoot, 1980).

#### D. TROPHIC STATE ANALYSIS

Emphasis was placed on the role of phosphorus in determining the productivity of Lake Hopatcong. For most temperate lakes, phosphorus is found to be the element which limits the amount of primary production, as represented by algae or aquatic plant growth. The importance of phosphorus stems from its low availability in the water column relative to the phosphorus requirements of algae and aquatic plants in photosynthesis and subsequent tissue production. As a result, phosphorus is usually depleted from the lake before other nutrients and thus becomes the factor that limits primary production.

A number of models have been developed which empirically calculate the trophic state of a water body on the basis of a few key parameters. The more commonly used models are reviewed by Reckhow (1979) in regard to their derivation, strength, shortcomings, and potential bias. In general, using annual TP loading, hydrologic, and morphometric data the spring total phosphorus concentration of a lake can be fairly accurately predicted. This information is important in that it provides an estimate of the amount of TP available for utilization by primary producers at the onset of the growing season. This is a determining factor of summer productivity in most lakes.

The Dillon (1974) model is one of the more popular and accurate models (Equation 1).

Equation 1: 
$$[P_s] = \frac{L(1-R)T}{Z}$$

Where:  $[P_s]$  = Spring total phosphorus concentration ( $\text{gm}^{-3}$ )  
 $L$  = Areal Load ( $\text{gm}^{-2}\text{yr}^{-1}$ ) = annual TP load/lake surface area  
 $Z$  = Mean depth (m)  
 $T$  = Hydraulic retention (yr)  
 $R$  = Phosphorus retention

Developed primarily for use with phosphorus-poor Canadian Shield lakes, it has been verified for use with north temperate, nutrient enriched lakes (Reckhow, 1977). Although a robust model, it may underestimate spring total phosphorus in highly enriched lakes, and overestimate spring total phosphorus in lakes with a large areal water load (ratio of lake outflow:lake surface area). Neither of these cases apply to Lake Hopatcong.

The phosphorus retention coefficient,  $R$ , of equation 1, is an important part of the model. It can be calculated on the basis of hydrologic data using a number of empirical models. In lakes which flush infrequently, as is the case for Lake Hopatcong, a model developed by Ostrofsky (1978) provides an accurate prediction of phosphorus retention. That model (equation 2) was used in this study to calculate  $R$ .

Equation 2:  $R_p = 0.201e^{(-0.0425q_s)} + 0.5743e^{(-0.00949q_s)}$

Where:  $R_p$  = Phosphorus retention  
 $q_s$  = Areal water load =  $\frac{\text{Annual Outflow from Lake}}{\text{Surface Area of Lake}}$   
 $e$  = Exponential of natural log  $e = 2.718$

The spring total phosphorus concentration generated by Equation 1, was plotted on a trophic status graph developed by Dillon (1974) for use in conjunction with that model. The graph is provided with acceptable and

dangerous loading levels. By plotting  $L(1-R)T$  vs.  $Z$ , an estimate of the lake's trophic status is obtained. This procedure was carried out for existing lake conditions using TP loading data calculated from unit areal phosphorus loading computations.

The calculated spring total phosphorus concentration of Lake Hopatcong is more meaningful when assessed in terms of lake productivity. That is, how much in-lake productivity, in the form of algae or aquatic macrophyte biomass, can be expected given a certain amount of phosphorus. The chlorophyll a model of Dillon and Rigler (1974) was used in this study (Equation 3).

Equation 3:  $\log_{10}[\text{Chla}_s] = 1.449 \log_{10} [\text{P}_{sp}] - 1.136$

Where:  $[\text{Chla}_s]$  = Summer chlorophyll a ( $\text{mg m}^{-3}$ )  
 $[\text{P}_{sp}]$  = Spring total phosphorus ( $\text{mg m}^{-3}$ )

The model was developed for use in lakes which have nitrogen:phosphorus ratios greater than 12:1 (potentially phosphorus limited). Such is the case for Lake Hopatcong where spring and summer nitrogen:phosphorus ratios are often >12:1 (USEPA, 1976).

It should be noted that the final predicted maximum chlorophyll a concentration is really a measure of potential primary production and general lake conditions. Other factors that affect primary production such as shading or competition for nutrients by macrophytes and benthic algae mats are not accounted for in the model. Thus, one expects discrepancies between actual measured values and predicted values of maximum chlorophyll-a in plankton samples. It may therefore be more appropriate to consider these values chlorophyll a equivalents, an estimate of total potential lake productivity.

An additional method was utilized to determine trophic status. The Trophic State Index (TSI) of Carlson (1977) was calculated from the mean summer Secchi disc transparency depth using the relationship:

$$\text{Equation 4: } \text{TSI (SD)} = 10 \left( \frac{6 - \ln \text{SD}}{\ln 2} \right)$$

Where: TSI (SD) = trophic status based on summer Secchi disc transparency

Ln = natural log

This in turn can be related to chlorophyll a concentration ( $\text{mg m}^{-3}$ ) using the relationship (Carlson, 1977):

$$\text{Equation 5: } \ln \text{SD} = 2.04 - 0.68 \ln \text{Chl a}$$

Where: SD = Secchi disc transparency depth (m)  
Chla = Chlorophyll a concentration ( $\text{mg m}^{-3}$ )

As Secchi disc depth is an easily measured parameter, this provides the user with a fairly easy means of determining both the trophic state of the lake and the maximum chlorophyll-a concentration to be expected under such conditions.

The utility of both the Dillon model and Carlson's TSI is in the future management of the lake. Through these models, it will be possible to easily obtain a preliminary estimate of how changes in phosphorus



loading will affect the trophic state of the lake, without the need to conduct a sampling program of the depth and scope of this study.